

--20. (new) The process according to claim 14, wherein the gradual depressurization takes place at a temperature range between 280°C and 150°C.

--21. (new) The process according to claim 20, wherein the temperature range is between 230°C and 170°C.

--22. (new) The process according to claim 14, further comprising the step of using phosphoric acid as a catalyst.

--23. (new) The process according to claim 14, further comprising the step of adding acetic acid as a catalyst.--

REMARKS

The application has been amended as needed so as to place it in condition for disposal at the time of the next Official Action.

In the course of this revision, subject headings have been inserted at the appropriate locations throughout the specification in a manner consistent with the preferred guidelines set forth at 37 CFR §1.77 and Section 601 of the Manual of Patent Examining Procedure (MPEP).

In addition, the specification has been extensively revised, so as to change terms spelled in the English version, to terms spelled in accordance with an American dictionary. Thus, the terms "pressurised" has been changed to --pressurized--, as was helpfully suggested by the Examiner in her Official Action.

Similar changes were made to correct the spelling of --depressurization--, --realization--, and --computerized--.

The claims were rejected under 35 USC §112, second paragraph, for indefiniteness. The Primary Examiner's well-taken formal criticisms of these claims were borne in mind as points to be corrected when drafting the new claims. Specifically, new claims 14-23 were drafted in such a manner as to particularly point out and distinctly claim the subject matter regarded by applicant as his invention. When drafting the new claims, great care was taken to ensure that the terms recited therein possessed proper antecedent basis. Moreover, the use of vague, indefinite, or otherwise objectionable expressions was avoided. Thus, new claims 14-23 are believed to set out and circumscribe a particular process for manufacturing furfural, with a reasonable degree of precision and particularity, when read in light of the teachings of the original specification. It is respectfully submitted that a person having ordinary skill in the art would be reasonably apprised of the metes and bounds of new claims 14-23. Accordingly, it is believed that the rejection of the claims under 35 USC §112, second paragraph, has been overcome and should not be applied to new claims 14-23.

Claims 1-10 were rejected under 35 USC §103(a) as being unpatentable over ZEITSCH 4,912,237. The Official Action states that the ZEITSCH reference discloses a process for producing furfural which is seen to include all of the essential steps

recited in applicant's claims, but appears to differ therefrom in failing to specify that the reaction medium is maintained in a constant ebullient state, and that phosphoric and acetic acids are used as catalysts. It is concluded that it would have been obvious to maintain a reaction medium which is kept in an ebullient state in view of the disclosure of ZEITSCH, because the latter infers that the reaction conditions are similar. In addition, it is advanced that the claimed features of feeding the mass material into the reactor, introducing pressurized steam to predetermined temperatures and depressurizing to a temperature sufficient to maintain the liquid phase would likewise have been obvious in view of the drawbacks of prior processes.

Reconsideration of the above rejection is respectfully requested for the following reasons.

It would appear that the Official Action has quite correctly distinguished between the process of the present application (Suprayield) and that of the ZEITSCH reference, which is also known as the Supratherm process. The Official Action recognizes that the present invention requires that the liquid fraction of the charge in the reactor must be maintained in a constant ebullient liquid state by subjecting it to a gradual reduction in pressure.

However, the Official Action then incorrectly deduces that it would have been an obvious expedient to apply a gradual reduction of pressure to the Supratherm process to produce a

comparable result. Another incorrect assumption is that one of ordinary skill in the art could simply optimize the reaction conditions of Supratherm to improve yield and selectivity.

In order to explain why the herein-claimed invention would not have been obvious to a person having ordinary skill in the art, a brief review of the Supratherm process is necessary. In the Supratherm process, a slurry of recycled mother liquor and feedstock is heated by condensing steam to a high temperature in the presence of a mineral acid, held in a continuous reactor at a controlled pressure long enough to produce furfural, then flashed to remove excess furfural that has been produced, and which can be recovered. The mother liquor which still contains furfural is filtered to remove the depleted feedstock. It is then further cooled, fresh feedstock is added, and the slurry is recycled. The process is continuous.

The process is carried out at a controlled temperature and pressure, and the reactions take place in the liquid phase with newly-produced furfural remaining in the liquid phase. This is evident from the accompanying Figure 1, which represents a phase diagram for furfural water. This point is depicted by A. The reactions take place in the liquid phase. Because the mother liquor has not been elevated to its boiling point, the furfural which is produced remains in the liquid phase and reacts with the pentose, which is dissolved in the mother liquor and suffers serious yield losses.

The mother liquor is heated by steam injection, that is, the condensation of water vapor. Pentosan in the feedstock is hydrolyzed to pentose, which immediately dissolves in the mother liquor, causing a significant rise in the boiling point of the mother liquor. Therefore, at any pressure, the condensation temperature of the water vapor (condensing steam) will always be lower than the boiling point of the pentose saturated liquor. It is therefore thermodynamically impossible to boil the mother liquor in the Supratherm process, no matter what pressure or amount of steam is used.

As the Supratherm reactor is maintained at a fixed pressure and temperature, a gradual decompression of the reactor is not possible and cannot be a simple or obvious expedient to a person having ordinary skill in the art. Such skilled artisan simply cannot boil the reactor.

Instead, what the present inventor deduced, was that in order to prevent the loss reactions (furfural-pentose) from occurring, the furfural had to be produced in a boiling mother liquor located within the dry feedstock used in the process. (See Figure 1, the phase diagram of furfural/water solutions at a range of temperatures). The boiling point of the mother liquor before the production of furfural, but after the production of pentose, would be W^* . The temperature difference between W and W^* is due to the boiling point elevation caused by the dissolved pentose in the mother liquor. A small amount of furfural is then

formed, point A*. It is evident from the accompanying phase diagram, that the furfural must instantly transfer to the vapor phase, and will remain there as long as the mother liquor continues to boil. It is therefore physically isolated from the pentose, which must remain in the liquid phase, and the furfural/pentose yield loss reactions cannot occur.

It might be argued that the obvious means to achieving a boiling mother liquor in a Supratherm reactor is the application of a different heat source (other than steam). However, indirect heating cannot be used due to fouling of heat exchange surfaces and the application of external heat to the reactor would be difficult and impractical because of the solid nature of the charge.

It is respectfully submitted that the herein-claimed process, which requires that the reactor contents be rapidly heated to a high temperature, and then a gradual depressurization be applied to induce boiling, such that the period of time required to decompress from a high primary pressure to a lower secondary pressure corresponds to the reaction time necessary for the desired conversion of pentosan to furfural, is neither disclosed, nor suggested by the patented ZEITSCH reference. Indeed, temperatures need to remain elevated to ensure that the desired reaction rate is maintained, and several heating/depressurization cycles may prove necessary (see accompanying Figure 2).

In view of the above remarks, it is respectfully submitted that the ZEITSCH reference simply fails to disclose or suggest a process for manufacturing furfural by carrying out the process steps recited in applicant's independent claim 14.

Consequently, it is believed that this application has been placed in condition for allowance. Reconsideration and allowance on the basis of new claims 14-23 are accordingly solicited.

In the event that there are any questions relating to this amendment or to the application in general, it would be appreciated if the Examiner would telephone the undersigned attorney concerning such questions so that the prosecution of this application may be expedited.

Attached hereto is a marked-up version of the changes made to the specification. The attached page is captioned "VERSION WITH MARKINGS TO SHOW CHANGES MADE."

Respectfully submitted,

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July 23, 2003

VERSION WITH MARKINGS TO SHOW CHANGES MADE

IN THE SPECIFICATION:

Page 2, the paragraph beginning on line 20 has been amended as follows:

--As the principal difference between the analytical furfural process of 100% yield and the industrial processes of less than 60% yield lies in the fact that in the first case the reaction medium is boiling while in the second case it is not boiling, it was compelling to create an industrial process in which the reaction medium is [maintaining] maintained in a state of boiling. In view of the fact that with giant furfural reactors, charged with solids not conductive to being stirred, an indirect energy input by heating the walls can be ruled out, it is the essence of this invention to bring about continuous boiling by a gradual (slow) [depressurisation] depressurization. In this fashion, a uniform boiling down to molecular dimensions is enforced without a need for mixing.--.

Page 3, the paragraph beginning on line 7 has been amended as follows:

--According to the invention, a process for the manufacture of furfural includes the steps of charging a reactor with a pentosan containing material, acidified or not, heating the charge by introduction of [pressurised] pressurized steam to a first predetermined temperature, closing the steam inlet valve of the reactor and subjecting the charge to a gradual reduction

of pressure until a second predetermined temperature is attained, the [depressurisation] depressurization maintaining the liquid phase within the reactor in a constantly boiling state.--;

Page 3, the paragraph beginning on line 13 has been amended as follows:

--In the preferred form the rate of [depressurisation] depressurization is sufficient to complete the conversion to furfural before a second predetermined temperature is attained. Also in the preferred form of the invention, the charge is acidified prior to heating.--;

Page 3, the paragraph beginning on line 16 has been amended as follows:

--Also in the preferred form of the invention, the gradual [depressurisation] depressurization comprises the controlled leaking of a stream of vapour from the reactor until the second predetermined temperature is attained.--;

Page 3, the paragraph beginning on line 19 has been amended as follows:

--In one form of the invention, a first [depressurisation] depressurization is followed by a reheating to a temperature at or near the first predetermined temperature, the reheating being followed by a second gradual [depressurisation] depressurization.--;

Page 3, the paragraph beginning on line 22 has been amended as follows:

--Subsequent reheating and [depressurisation] depressurization cycles may also be employed if required.--;

Page 3, the paragraph beginning on line 23 has been amended as follows:

--In one form, steam may be added during [depressurisation] depressurization to increase the reaction temperature and improve yield.--.

Page 4, the paragraph beginning on line 5 has been amended as follows:

--Also in the preferred form of the invention the gradual [depressurisation] depressurization takes place in the temperature range between 280° Celsius and 150° Celsius, however the preferred range of operation is between 230° Celsius and 170° Celsius.--;

Page 4, the paragraph beginning on line 8 has been amended as follows:

--By an appropriate choice of the first and second temperatures, and by appropriate selection of a mineral or organic acid concentration, it is possible, if desired, to complete the process in a single [depressurisation] depressurization period since high temperatures and high acidity result in a short reaction time.--;

Page 4, the paragraph beginning on line 16 has been amended as follows:

--The outlet includes, after a valve, an orifice plate of predetermined dimensions for assisting in controlling the rate of [depressurisation] depressurization. In this form, the valve and orifice plate may be operated in tandem to obtain a range of [depressurisation] depressurization rates or a flow control valve governed by temperature or pressure can be used.--;

Page 4, the paragraph beginning on line 21 and bridging pages 4 and 5 has been amended as follows:

--In an alternative form of the invention the reactor walls are designed to be heated. Also in this form, all valve operations are preferably controlled automatically by a [computerised] computerized control unit. It has been demonstrated experimentally, on a pilot plant scale, that by maintaining the liquid phase of the reaction medium in a state of boiling throughout the reaction period, the furfural yield obtained is substantially greater than current commercial processes, and if correctly controlled may approach yields achieved in the analytical furfural process. The Applicant contends further that apart from increasing the yield, the process of the invention is operable at substantially lowered capital and production costs, for the following reasons:

(1), The process of the invention does not use steam for stripping furfural from the mass of feed material as once the

reactor is sufficiently heated, the steam inlet is closed. Further steam will only be required briefly if a reheating cycle is employed.

(2), As a result of the non-use of steam to strip the furfural, the volume of condensate existing the reactor is significantly reduced and the concentration of furfural therein will be proportionately increased in relation to existing processes. This increased furfural concentration will greatly simplify the primary azeotropic distillation. In special cases, for instance in the application of the furfural as a nematicide, no distillation is needed at all.

(3), The product of the invention contains less acetic and formic acid (formed from the raw material) since, after reaching the second predetermined temperature of the decompression, most of these by-products are discharged with the residue. This greatly reduces the loading of the effluent generated by the plant.--.

Page 5, the heading on line 18 has been amended as follows:

--DETAILED DESCRIPTION OF THE INVEWNTION--.

Page 5, the paragraph beginning on line 21 and bridging pages 5 and 6 has been amended as follows:

--A thermally well insulated reactor 1 charged with raw material acidified or not, is heated to a temperature T_1 by admitting steam through valve 2 while the valves 3 and 4 are

closed. During the very short heating process, the steam condenses, thus increasing the moisture content of the charge. Then, valve 2 is closed and a leak valve 3 is opened so as to produce a steady small flow of product vapour by gradual [depressurisation] depressurization. This causes a slow drop in temperature. When in this fashion a suitably chosen temperature T_2 is reached, the leak valve 3 is closed to terminate the first "gradual [depressurisation] depressurization". If at the end of this period no more furfural was obtained, the digestion is completed by opening valve 4 to discharge the residue. If, however, furfural was still obtained, the reactor is reheated and submitted to another "gradual [depressurisation] depressurization" period. This procedure can be arbitrarily repeated. All valve operations are governed by an automatic control unit 5.--.

Page 6, the paragraph beginning on line 4 has been amended as follows:

--By an appropriate choice of the temperatures T_1 and T_2 , and by an appropriate choice of the acid concentration, it is possible, if desired, to complete the process in a single [depressurisation] depressurization period since high temperature and high acidity permit a short reaction time.--;

Page 6, the paragraph beginning on line 8 has been amended as follows:

--Needless to say, designing such an operation is complicated as the furfural reaction takes place over a wide range of temperatures (e.g. from 230°C to 160°C), but once calculated, the practical [realisation] realization of the process is extremely simple.--.